TECHNICAL MANUAL

OPERATION and MAINTENANCE

DC POWER SUPPLY

TCR SERIES
MODEL TCR 10-38

JULY 1964

MP MASTER
MA29438

ac-dc power supplies

BEHLMAN-INVAR
ELECTRONICS CORP.

1723 CLOVERFIELD BLVD.
SANTA MONICA, CALIF.

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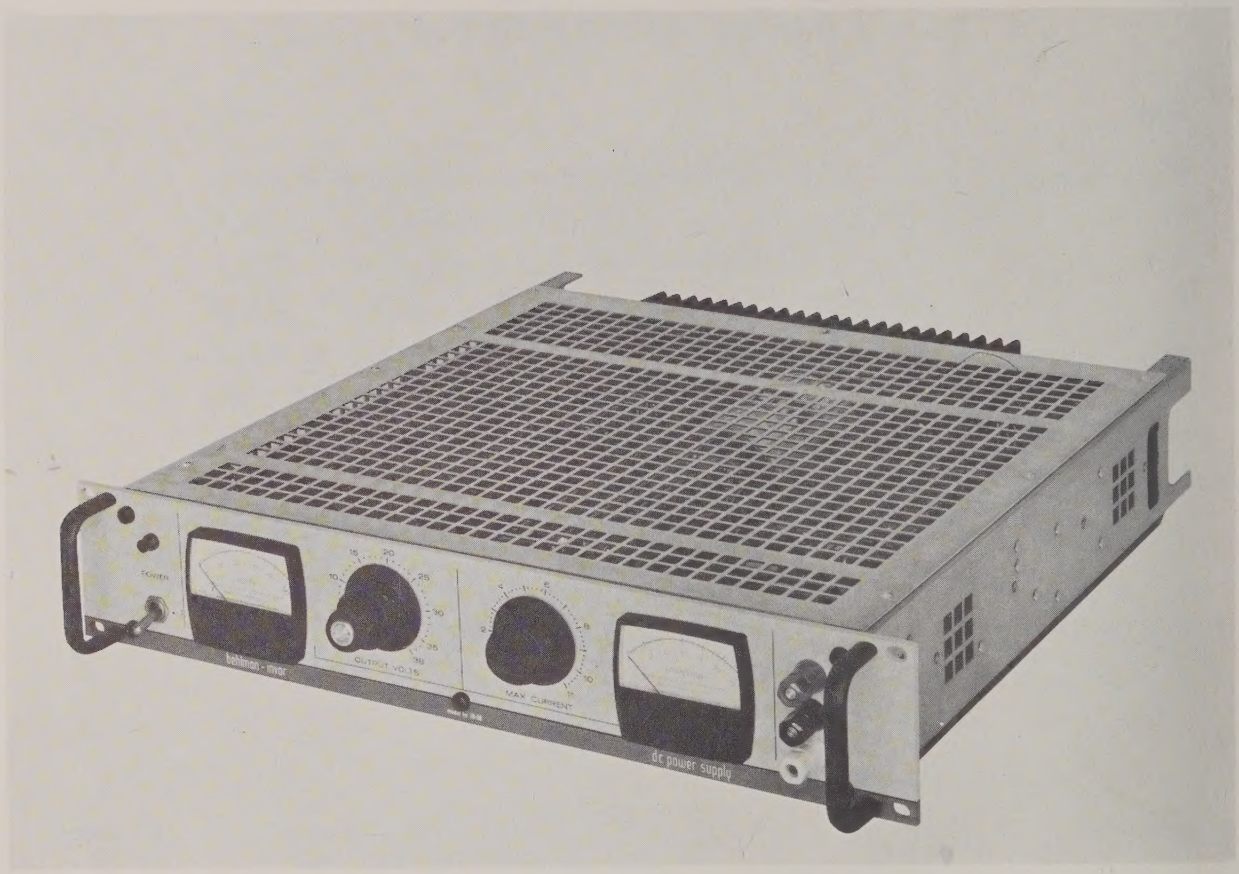


Figure 1-1. Model TCR 10-38 DC Power Supply

SECTION 1

DESCRIPTION AND SPECIFICATIONS

1.1 INTRODUCTION

1.1.1 This manual provides a general description, theory of operation, and operating and maintenance instructions for the Behlman-Invar Model TCR 10-38 DC Power Supply.

1.1.2 In common with all models of the Behlman-Invar TCR Series of solid state DC Power Supplies, the Model TCR 10-38 Power Supply combines both high wattage capability and high stability of operation in an extremely compact package. The Model TCR 10-38 Power Supply, which may be operated in either a constant voltage mode or a constant current mode, utilizes electronic pre-regulation followed by series transistor regulation to achieve exceptional performance and extended service life of the regulatory components.

1.2 GENERAL FUNCTIONAL DESCRIPTION

1.2.1 Constant Voltage and Constant Current Operation. The Model TCR 10-38 provides constant voltage operation over a continuously variable output voltage range of 0-38 volts and constant current operation over a continuously variable output current range of 0-10 amperes. Constant current operation can be maintained at any selected point in the 0-10 ampere output current range throughout the entire output voltage range of the power supply. The unit will operate in the constant voltage mode until the output current demand exceeds a pre-selected value, at which time the unit will automatically transfer to the constant current mode of operation.

1.2.2 Remote Programming. The TCR 10-38 circuits provide for full-range remote programming (or control) of both the voltage and current outputs. Remote programming operation is obtained by means of simple resistive circuit connections to a rear-mounted terminal board. The voltage programming characteristic is approximately 131 ohms/volt; current programming being provided by a 1000-ohm potentiometer.

1.2.3 Remote Sensing. Incorporated in the power supply is a remote sensing circuit that permits power supply output voltage regulation to be controlled by means of the voltage sensed at the power supply output load. This feature ensures that the voltage applied to the load remains constant within the power supply voltage regulation specifications despite a nominal voltage drop along the (output) power line.

1.2.4 Parallel Operation. Provision is made for the connection of several TCR 10-38 Power Supplies in parallel to provide increased load current. Proper combined operation of the power supplies is assured by circuit provisions wherein one ("master") power supply controls the regulatory circuits of all the power supplies. This provision retains the remote sensing feature, which is effected by means of the "master" power supply.

1.3 SPECIFICATIONS AND PERFORMANCE DATA

1.3.1 Refer to Table 1-1 for specifications and performance data for the Model TCR 10-38 Power Supply.

TABLE 1-1. SPECIFICATIONS AND PERFORMANCE DATA

Output Voltage and Current:	0-38 Volts DC 0-10 Amperes
Input Power Requirements,	
Voltage:	at 115V tap, 115V ±10V, 47-63 CPS at 120V tap, 120V ±10V, 47-63 CPS
Current:	8 Amps RMS at 120 VAC and full load
Power Factor:	0.5 current lagging
Efficiency:	65% at full load (power factor corrected)
CONSTANT VOLTAGE OPERATION	
Static Regulation Load 0-10 Amps,	
At Front Panel Terminals:	±0.0079% or 3 MV*
At Rear Panel Terminals:	±0.0026% or 1 MV*
Using Remote Sensing:	±0.0026% or 1 MV* (with up to 3V line drop at 38V output)
Line Voltage ±10V:	±0.0026% or 1 MV*
Dynamic Regulation (Line ±10 Volts, Load 0-10 Amps),	
Response Time:	100 μ SEC to 37% of Peak
Peak:	300 MV Max.
Ripple:	0.0026% or 1 MV RMS*

*whichever is greater

TABLE 1-1. SPECIFICATIONS AND PERFORMANCE DATA (continued)

Stability:	±15MV/8 HRS. (After 30 min. warm up)
Temperature Coefficient:	±0.01%/Deg. C

CONSTANT CURRENT OPERATION

Regulation,	
Line Input: 105-125 Volts:	0.16% or 16 MA*
Compliance 0-38 Volts:	0.08% or 8 MA*
Ripple:	0.03% or 3 MA RMS*

ENVIRONMENT

Temperature Range:	0-50°C
Means of Cooling:	Convection

MECHANICAL DESCRIPTION

Width:	19 INCHES
Height:	3.5 INCHES Max.
Depth behind panel:	18.5 INCHES Max.
Weight:	55 POUNDS
Mounting:	Rack mounted, with provision for "Chassis Trak" Slides

FEATURES

1. Remote Voltage Programming: approximately 131 ohms/volt
2. Remote Current Programming: 1000-ohm potentiometer
3. Parallel Operation
4. Short Circuit and/or Overload Protection (Auto Reset)

*whichever is greater

SECTION 2

CIRCUIT DESCRIPTION

2.1 GENERAL FUNCTIONAL DESCRIPTION

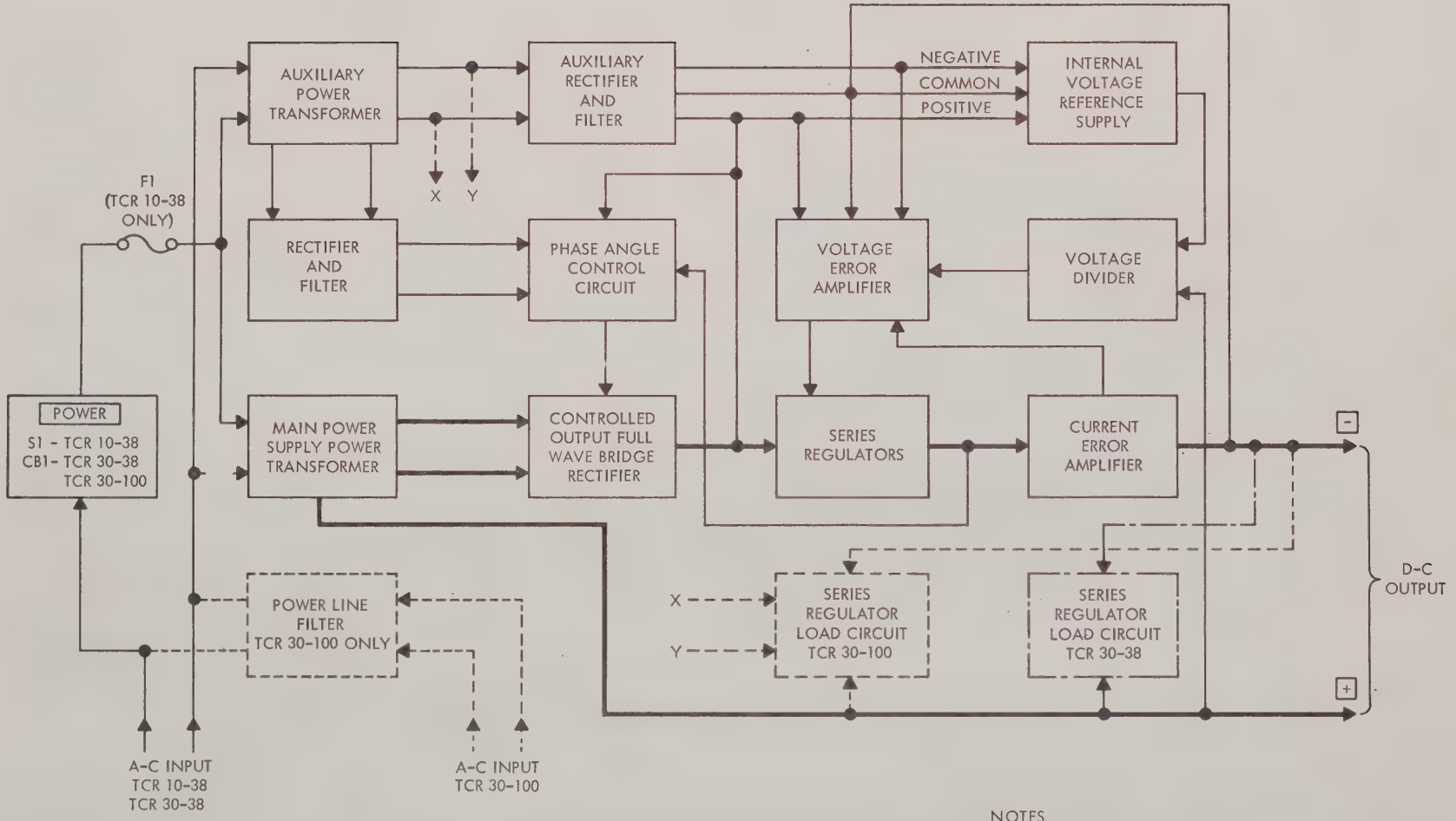
2.1.1 The basic circuit of the Model TCR 10-38 DC Power Supply is shown in the block diagram of Figure 2-1 (also see the schematic diagram, Figure 4-1). Principal circuits of the power supply are as follows: the main power supply rectifier, which is a full wave bridge rectifier incorporating two silicon controlled-rectifiers; a series (or pass) regulator; current error and voltage error amplifier stages; a silicon controlled-rectifier (SCR) phase angle control circuit; and auxiliary power supply and reference voltage circuits. Electronic voltage pre-regulation is provided by the SCR and phase angle control circuits; conventional voltage and current regulation being accomplished by the series regulator and current and voltage error amplifiers. The pre-regulator circuit operates in a feedback-type control circuit that functions to maintain the voltage drop across the series regulators at a relatively constant, low value. The auxiliary power supply and reference voltage circuits provide all d-c power requisite for the operation of the regulatory circuits.

2.2 CIRCUIT DESCRIPTION

2.2.1 A-C Input Circuit. The a-c input circuit includes POWER switch S1 and POWER indicator lamp DS1, fuse F1, and transformers T1 and T2. Transformer T1 is the main power supply transformer and transformer T2 powers the auxiliary power supply circuits.

2.2.2 Main Power Supply Circuit. The main power supply circuit includes transformer T1, the controlled full wave bridge rectifier comprised of diodes CR4 and CR5 and SCR's CR1 and CR2, choke-input filter L1/C3, and parallel-connected series regulator transistors Q9 through Q11. Operation of the series regulator and pre-regulation portions of the main power supply circuit is as follows:

a. The output voltage of the power supply is controlled directly by the series regulator circuit. An increase in the effective resistance of the regulator circuit increases the voltage drop across the regulator and thereby reduces the power supply output voltage. Similarly, a decrease in the effective resistance of the regulator circuit results in an increase of the power supply output voltage. When the power supply is operating in the constant voltage mode, the voltage drop across the series regulator is governed by the voltage error amplifier, which monitors the power supply output voltage. During the constant current mode of operation, the voltage drop across the series regulator is controlled by the



NOTES

1. UNLESS OTHERWISE INDICATED, ALL CIRCUITS AND STAGES ARE COMMON TO TCR 10-38, TCR 30-38, AND TCR 30-100 POWER SUPPLIES.
2. ----INDICATES CIRCUIT PECULIAR TO TCR 30-100 ONLY.
3. ---INDICATES CIRCUIT PECULIAR TO TCR 30-38 ONLY.
4. ——— HEAVY LINES DENOTE MAIN SIGNAL PATHS.

Figure 2-1. Model TCR 30-100 DC Power Supply, Block Diagram

current error amplifier, which monitors the power supply output current. The voltage error amplifier adjusts the voltage drop across the series regulator to compensate directly for power supply output voltage variations. The current error amplifier compensates for any tendency of the output current to rise by increasing the voltage drop across the series regulator sufficiently to constrain the power supply output current to the pre-selected level.

b. The pre-regulator circuit, which monitors the voltage drop across the series regulator, operates in synchronism with the variations in series regulator voltage drop effected by the constant current and constant voltage error amplifiers. When the voltage drop across the series regulator tends to increase, the pre-regulator reduces the series regulator input voltage, thereby maintaining the voltage drop below a pre-established maximum value. When the series regulator voltage drop tends to decrease, the pre-regulator circuit raises the voltage applied to the series regulator sufficiently to maintain the voltage drop within the required limits.

2.2.3 Pre-Regulator Circuit Operation. Pre-regulator circuit operation is based upon phase control of the main power supply bridge rectifier elements to regulate the voltage applied to the power supply series regulators. The SCR elements of the rectifier bridge pass no current until triggered by a "gate" voltage. Once the gate voltage is applied, the SCR elements will continue to conduct until the gate voltage is removed. The phase angle control circuit supplies a gate voltage to the SCR elements at some point (in time) of each half cycle of the a-c input to the rectifier; the gate voltage being automatically removed at the end of each half cycle. The "firing," or phase, angle during each half cycle of the a-c input is so controlled that the average power applied to the rectifier filter (and the resultant filter output voltage) properly compensate for the variations in power supply series regulator voltage drop.

a. The phase angle control circuit consists essentially of a "sawtooth" oscillator and a voltage comparison circuit. The circuit receives as an input a signal representing the voltage drop across the series regulator and processes this input to derive an output that controls the conduction time, or firing angle, of the bridge rectifier SCR elements.

b. The sawtooth oscillator produces a ramp voltage that is applied, as one of two inputs, to the voltage comparison circuit. The other input to the voltage comparison circuit is a voltage representing the voltage drop across the series regulator circuit. The output of the voltage comparison circuit is applied to the control elements of the SCR's, where it initiates current flow through the SCR's. The voltage comparison circuit produces a gate voltage output whenever the ramp voltage and the series regulator voltage drop are equal in magnitude. A high voltage drop will require the ramp voltage to approach its maximum value before the comparison circuit produces an output and the duration of the gate voltage

output of the circuit represents a small portion of the duration of each sawtooth (ramp voltage) cycle. Under this condition, the conduction time of the rectifier bridge SCR's is reduced and the voltage applied to the series regulator circuit is also reduced, thereby decreasing the series regulator voltage drop.

c. Conversely, a decrease in the series regulator voltage drop will cause the voltage comparison circuit to initiate an output at a lower sawtooth ramp voltage and to maintain this output for a greater portion of each ramp voltage cycle (than would be obtained under a condition of high series regulator voltage drop). The result of this condition is that the SCR gate voltage output of the phase angle control circuit is of greater duration, thereby increasing the conduction time of the rectifier bridge and increasing the level of the voltage supplied to the series regulator sufficiently to maintain the voltage drop at, or above, the required minimum value.

2.2.4 Voltage Error Amplifier. The voltage error amplifier circuit is typical of those utilized in conventional series-type voltage regulator circuits. The error amplifier compares the output voltage of the power supply with a reference voltage established by the setting of the fine and coarse OUTPUT VOLTS control potentiometers (R8 and R10) and produces an output that effectively is opposite in magnitude and direction to the undesired variation of the power supply output voltage. This output is applied to the series regulator circuit, where it adjusts the series regulator voltage drop in a direction necessary to nullify the change in power supply output voltage.

2.2.5 Current Error Amplifier. The current error amplifier compares the voltage drop produced by power supply output current flow through a series resistor with a reference voltage established by the setting of MAX CURRENT control potentiometer R5. An increase in output current demand as evidenced by increased voltage drop across the series resistor causes the current error amplifier to increase the voltage drop across the power supply series regulator and thereby reduces the output voltage to a level insufficient to maintain the increased current flow. Similarly, a tendency toward reduced current flow causes the current error amplifier to reduce the voltage drop across the power supply series regulator and thus provide sufficient output voltage to produce the pre-established maximum current flow.

SECTION 3

INSTALLATION AND OPERATION

3.1 GENERAL

3.1.1 This section provides instructions concerning installation and operation of the Model TCR 10-38 DC Power Supply (see Figures 3-1 and 3-2). Instructions provided include those for connection to the primary a-c power source, connections to the power supply output, and connections for various modes of operation. In addition, adjustment data and normal operating procedures as required are included.

3.2 PRIMARY AC INPUT POWER CONNECTIONS

3.2.1 To connect the TCR 10-38 to the primary a-c power source, connect the female plug on the a-c line cord to J1 and insert the male line plug into a standard (3-pin) grounded a-c receptacle. It should be noted that the power supply is normally supplied wired for operation with a 115 ±10 vac input and, if it is necessary to power the unit with 120 ±10 vac power, the lead connected to tap number 2 of transformer T1 must be removed and reconnected to tap 3 of T1.

CAUTION

Before energizing the power supply, determine the type of operation desired and verify that the remote sensing terminals of TB2 (-RS, TB2-4 and +RS, TB2-3) are connected either to the power supply load or to terminals TB2-5 and TB2-2, respectively. Also, make certain terminal TB2-8 is connected either to TB2-7 (independent operation or as "master" supply) or to TB2-7 of a related power supply (parallel operation).

3.3 POWER SUPPLY OUTPUT CONNECTIONS

3.3.1 Connect the power supply load to either the "+" and "-" output binding posts on the front panel of the unit or to -OUT and +OUT terminals 2 and 5 of TB2, making certain to observe proper polarities. Either output terminal of the power supply may be grounded at the front panel by connecting a jumper between the desired output binding post and the ground binding post, and at the rear panel by connecting TB2-2 or TB2-5 to TB2-1.

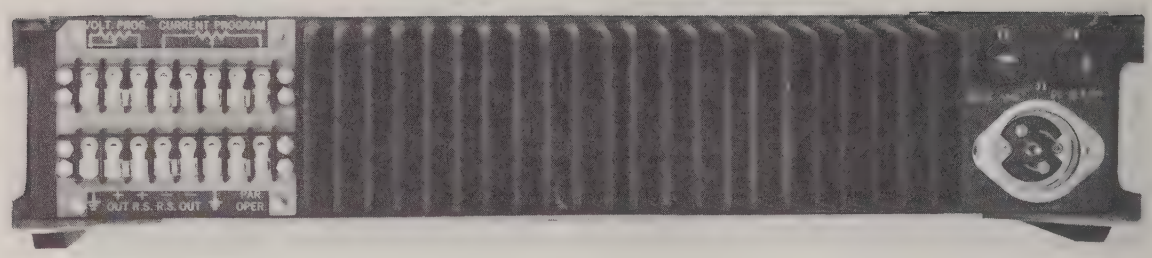


Figure 3-1. Model TCR 10-38 DC Power Supply, Rear

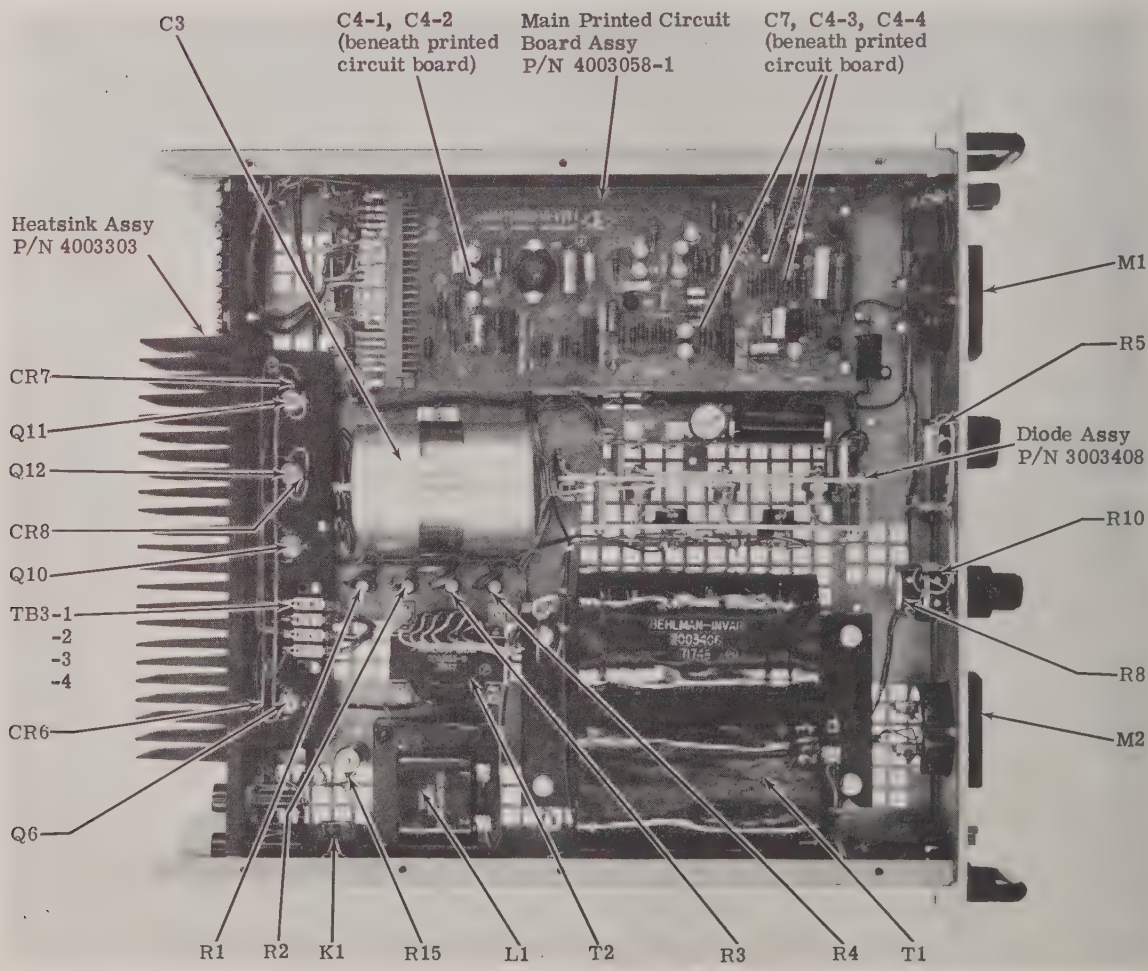


Figure 3-2. Model TCR 10-38 Power Supply, Top

3.3.2 Parallel Power Supply Operation Connections. To connect the outputs of several power supplies in parallel, connect together the -OUT terminals, then the +OUT terminals of the power supplies. Designate one power supply as the "master" supply, then remove the jumpers connecting PAR. OPER. terminals TB2-7 and TB2-8 of the "slaved" supplies and connect terminal TB2-8 of each of these supplies to terminal TB2-7 of the "master" supply.

3.4 REMOTE SENSING CIRCUIT CONNECTIONS

3.4.1 Single Power Supply. To use the remote sensing feature with a single (i.e., independently operated) power supply, on terminal board TB2 remove the jumpers connecting the -RS to the -OUT terminals, the +RS to the +OUT terminals and connect the +RS and -RS terminals directly to the power supply load. Be certain to observe proper polarity.

3.4.2 Paralleled Power Supplies. To employ the remote sensing procedure with parallel-connected power supplies, first connect the power supplies together as described in paragraph 3.3.2, then make the remote sensing circuit connections to the "master" supply as described in paragraph 3.4.1 for the single power supply.

3.5 REMOTE VOLTAGE PROGRAMMING CONNECTIONS

3.5.1 Remote voltage programming is accomplished by removing the jumper connecting terminals 2 and 3 of terminal board TB1 and then connecting a 5000-ohm remote programming potentiometer to terminals 1, 2, and 3 of TB1 as indicated on the connection diagram located adjacent to the above terminals of TB1.

3.6 REMOTE CURRENT PROGRAMMING CONNECTIONS

3.6.1 Remote current programming is accomplished by removing the jumpers connecting terminals 4 and 5 and 7 and 8 of TB1 and connecting a 1000-ohm remote programming potentiometer to terminals 4, 6, and 8 of TB1 as indicated on the connection diagram located adjacent to the above terminals of TB1.

3.7 CONTROLS AND INDICATORS

3.7.1 The Model TCR 10-38 front panel controls and indicators, and the functions thereof, are as follows:

POWER switch	Applies primary a-c power to the power supply.
POWER indicator lamp	Lights to indicate that primary a-c power is applied to power supply.

OUTPUT VOLTS control	A dual concentric control enabling power supply output to be varied through a range of 0 to 38 volts. Outer knob provides a coarse adjustment and the inner knob provides a fine adjustment.
MAX. CURRENT control	Enables selection of maximum output current at any point between 0 and 10 amperes.
VOLTS meter	Monitors power supply output voltage.
AMPERES meter	Monitors power supply output current.

3.8 OPERATING PROCEDURES

3.8.1 To operate the power supply proceed as follows:

a. Check that the intended load is properly connected to the front panel binding posts (J3, -OUT and J4, +OUT) or to terminals 2 and 5 of terminal board TB2.

b. Check that, where necessary, the positive or negative output circuit of the power supply is grounded to binding post J5, or to terminal 1 of TB2.

c. Check that the following connections (where used) have been completed correctly.

(1) Parallel connection to other power supply unit(s), refer to paragraph 3.3.2.

(2) Remote sensing (refer to paragraphs 3.4.1 and 3.4.2).

(3) Remote voltage programming (refer to paragraph 3.5.1).

(4) Remote current programming (refer to paragraph 3.6.1).

d. Place the MAX. CURRENT and OUTPUT VOLTS controls in the "0" positions.

e. Place the POWER switch in the "on" position and note that POWER indicator lamp lights.

f. Adjust the MAX. CURRENT and OUTPUT VOLTS controls to produce the required power supply output voltage and the maximum output current. Refer to VOLTS and AMPERES meters to verify power supply output characteristics.

SECTION 4

MAINTENANCE

4.1 GENERAL

4.1.1 This section covers both preventive maintenance and corrective maintenance of the TCR 10-38 Power Supply. Careful and regular performance of periodic maintenance upon the power supply will reduce the probability of failure and subsequent need for corrective maintenance. The preventive maintenance procedures contained herein include certain basic performance checks and the related adjustments required to establish proper equipment performance. In all cases of improper equipment performance, the basic checks (and, where necessary, appropriate adjustment procedures) should be accomplished prior to subjecting the equipment to detailed troubleshooting procedures. Refer to the schematic diagram of Figure 4-1 as an aid in the performance of maintenance upon the power supply.

4.2 TEST EQUIPMENT

4.2.1 Test equipment required for maintenance of the power supply is listed in Table 4-1.

TABLE 4-1. RECOMMENDED TEST EQUIPMENT

NOMENCLATURE	PART NO. OR MODEL	APPLICATION
Multimeter	Triplett Model 630 PL, or equivalent	General a-c and d-c voltage, and resistance measurements
Differential DC Voltmeter	John Fluke, Model 823	Line and static load regulation tests
Ammeter, 0-10 Ampere DC	Weston, Model 9992, Type 41196	General current measurements
Segmental Voltmeter, 100-130 VAC	Simpson, Model 1349C	Monitoring variable autotransformer output voltage
Variable Autotransformer, 0-140 VAC, 7.5 amperes	Superior Electric, Type 116	Checks of power supply regulation characteristics
Variable Load Resistance, 0-10 Ohm, 1000 Watt	Ohmite, Model K	Variable power supply load
Mercury Switch With Insulated Case, 30 Ampere	Durakool	Dynamic regulation tests

4.3 CLEANING

4.3.1 Remove dust, dirt, and other foreign material using a small brush and vacuum cleaner. Low pressure air may be used if a vacuum cleaner is not available. When using the air, be sure to aim the air stream so that the foreign material will be blown away from the unit being cleaned, rather than into recesses, slots, etc. Use a cloth and a suitable solvent to remove material not removable by means of the above procedure.

4.4 OPERATION CHECK AND ADJUSTMENT PROCEDURES

4.4.1 The following procedures provide a means of evaluating the performance of all major circuits of the power supply. DO NOT ATTEMPT to perform any of the following checks and adjustments unless the test equipment (or equivalent) listed in Table 4-1 IS AVAILABLE.

4.4.2 Preliminary Adjustments. Proceed as follows:

a. Place the POWER switch in the "off" position, then remove Main Printed Circuit Board Assembly P/N 4003058-1 from the chassis and make the following adjustments:

(1) Rotate VOLTAGE CALIB. ADJ. potentiometer R35 to the mid-point position.

(2) Rotate SER. REG. VOLT. DROP ADJUST potentiometer R13 to the mid-point position.

(3) Rotate CURRENT CALIB. ADJ. potentiometer R30 fully CCW (to the maximum resistance position).

b. Replace the printed circuit board assembly in the chassis.

c. Set the MAX. CURRENT control on the front panel fully CW.

d. Set the coarse and fine OUTPUT VOLTS controls on the front panel fully CCW.

e. Connect a jumper between negative output binding post J3 and chassis ground binding post J5 on the front panel.

4.4.3 Power Supply Unit Test Connections. Proceed as follows to interconnect the power supply and the test equipment (refer to Table 4-1).

NOTE

Complete all connections between the power supply and the test equipment, wherever possible, with shielded cables.

a. Connect the power supply ac line cord to the variable autotransformer output circuit and connect the expanded scale (segmental) a-c voltmeter across the autotransformer output circuit.

b. Connect the variable autotransformer power cord to an a-c receptacle.

c. Connect the differential voltmeter across the Power Supply panel-mounted output binding posts (J3 and J4) or to terminals 2 and 5 of TB2.

d. Connect the mercury switch and the variable load resistance across power supply output binding posts J3 and J4 or to terminals 2 and 5 of TB2.

4.4.4 Voltage Calibration.

a. Connect the equipment as described in paragraph 4.4.3.

b. Apply 115 VAC 60-cps line power to the variable autotransformer and adjust the variable autotransformer to produce an output of 115 ±1.15 VAC.

c. Place the POWER switch in the "on" position and note that the indicator lamp directly above the POWER switch lights.

d. Rotate the coarse OUTPUT VOLTS control on the front panel to the 25-volt position.

NOTE

Maintain the fine OUTPUT VOLTS control in the maximum CCW position unless otherwise directed.

e. Verify that the front panel VOLTS meter (hereafter referred to as the voltmeter) indicates approximately 25 volts.

f. Adjust R35 to produce a 25-volt indication on the front panel voltmeter.

g. Set the variable load resistance to 10 ohms and turn on the mercury switch.

h. Set the coarse OUTPUT VOLTS control to the maximum CCW position.

i. Slowly rotate the OUTPUT VOLTS control until the panel meter voltage indication starts to increase. Verify that the voltmeter indication and the OUTPUT VOLTS control setting coincide at zero. If the voltmeter indication does not coincide with the OUTPUT VOLTS control setting, loosen the two set screws on the control knob and set the knob pointer to coincide with the meter reading. Tighten the two set screws on the OUTPUT VOLTS control knob and re-check for accuracy at 0 volts and at 25 volts.

j. Set coarse OUTPUT VOLTS control to 38 volts and adjust R35 to produce an indication of 38 volts on the panel voltmeter.

k. Note that the differential voltmeter indicates 38 volts.

l. De-energize the equipment and disconnect the test equipment from the power supply.

4.4.5 Current Calibration.

a. Connect the equipment as described in paragraph 4.4.3.

b. Apply 115 VAC, 60-cps line power to the variable autotransformer and adjust the variable autotransformer to produce an output of 115 ±1.15 VAC.

c. Energize the TCR 10-38 and adjust the OUTPUT VOLTS control for a 38-volt power supply output.

d. Connect multimeter, set on 25 VDC scale, between the collector and emitter of one of the pass transistors (Q9, Q10, or Q11) located on large heat sink mounted on the rear of the test unit. (Observe polarity: positive lead to emitter, negative lead to collector.)

e. Turn on the mercury switch and adjust R13 to produce a 12-volt drop across the pass transistors, as indicated on the multimeter.

f. Set the MAX. CURRENT control to 5 amperes.

g. Turn on the mercury switch and reduce the variable load resistance until the ammeter indicates 6 amperes, or until the meter no longer indicates an increase in current, whichever occurs first.

h. Adjust R30 to produce an ammeter indication of 5 amperes.

i. Adjust the load resistance to produce minimum output current.

j. Rotate the MAX. CURRENT control fully CCW, then rotate the control CW slowly and note point at which the ammeter needle moves away from 0. If necessary, loosen the control set screws and re-position knob so that knob pointer is at 0.

k. Rotate the MAX. CURRENT control to the 10 ampere position, then adjust the variable load resistance to produce an ammeter indication of 10.5 amperes, or until the current will no longer increase. If necessary, adjust R30 to produce a 10-ampere indication on the ammeter. Do not increase the current beyond 11 amperes.

NOTE

If difficulty arises in the form of low frequency oscillation (motor boating) in the output voltage, re-adjust R13 to produce a slightly higher voltage drop across pass transistors. However, DO NOT EXCEED a 6-volt drop with a 10-ampere load current.

l. Check the accuracy of the MAX. CURRENT control knob pointer position by rotating the knob CCW from the 10-ampere position to the 0-ampere position and observing the agreement between the knob pointer position on the associated dial and the ammeter indication. The maximum observed discrepancy should not exceed 0.25 ampere. If the deviation exceeds 0.25 ampere, repeat the procedure of step j of this paragraph.

m. Adjust the variable load resistance to produce a minimum current indication on the ammeter and adjust the OUTPUT VOLTS control to produce a 38-volt indication on the panel voltmeter.

n. Rotate the MAX. CURRENT control fully CW. Adjust the variable load resistance to slowly increase the load current to 10 amperes, then adjust the variable autotransformer to provide a 125 vac input to the power supply.

o. Connect the multimeter across the collector and emitter of the pass transistor Q9, Q10, or Q11 and adjust SER. REG. VOLT. DROP ADJUST control R13 to produce a 5.0-volt drop across the pass transistor. Leave the multimeter connected across the pass transistor.

p. While monitoring the multimeter and the panel-mounted ammeter and voltmeter, slowly adjust the variable load resistance toward the minimum resistance position. The panel ammeter should continue to indicate 10 amperes and the panel voltmeter should begin to indicate a slight reduction in output voltage. Continue this procedure until the voltmeter indicates 36 volts. At this point, the power supply has transferred to the constant current mode of operation.

q. The multimeter should continue to indicate a pass transistor voltage drop of 5.0 volts as in step o above.

r. If the voltage drop across the pass transistor should exceed 5.0 volts, adjust the variable load resistance to produce the highest voltage drop, then adjust CURRENT CALIB. ADJ. control R30 to produce a voltage drop of 5.0 volts.

s. Adjust the variable load resistance to the maximum resistance condition and rotate the MAX. CURRENT control CW to the 0 ampere position.

t. De-energize the equipment and disconnect the test equipment from the power supply.

4.5 TROUBLESHOOTING

4.5.1 Troubleshooting techniques normally used with transistorized equipment are appropriate for the power supply. Prior to initiating detailed troubleshooting procedures in those cases where the power supply is operative, but not functioning properly, the following procedures are suggested:

a. Check the output connection, the local sensing jumpers, or when used, the remote sensing connections, for security. Imperfect connections at any of these points can seriously impair the voltage regulating function.

b. Check the power supply adjustments as detailed in paragraphs 4.4.4 and 4.4.5. In many cases it will not be necessary to perform all of the adjustments, as the particular type of power supply malfunction will frequently suggest the adjustments to be checked. DO NOT, however, ATTEMPT to perform any of these adjustments, unless the test equipment (or equivalent) listed in Table 4-1 IS AVAILABLE.

4.6 REPAIR AND REPLACEMENT

4.6.1 When reconnecting or replacing electrical parts, observe the usual standards of good practice, paying particular attention to the following points:

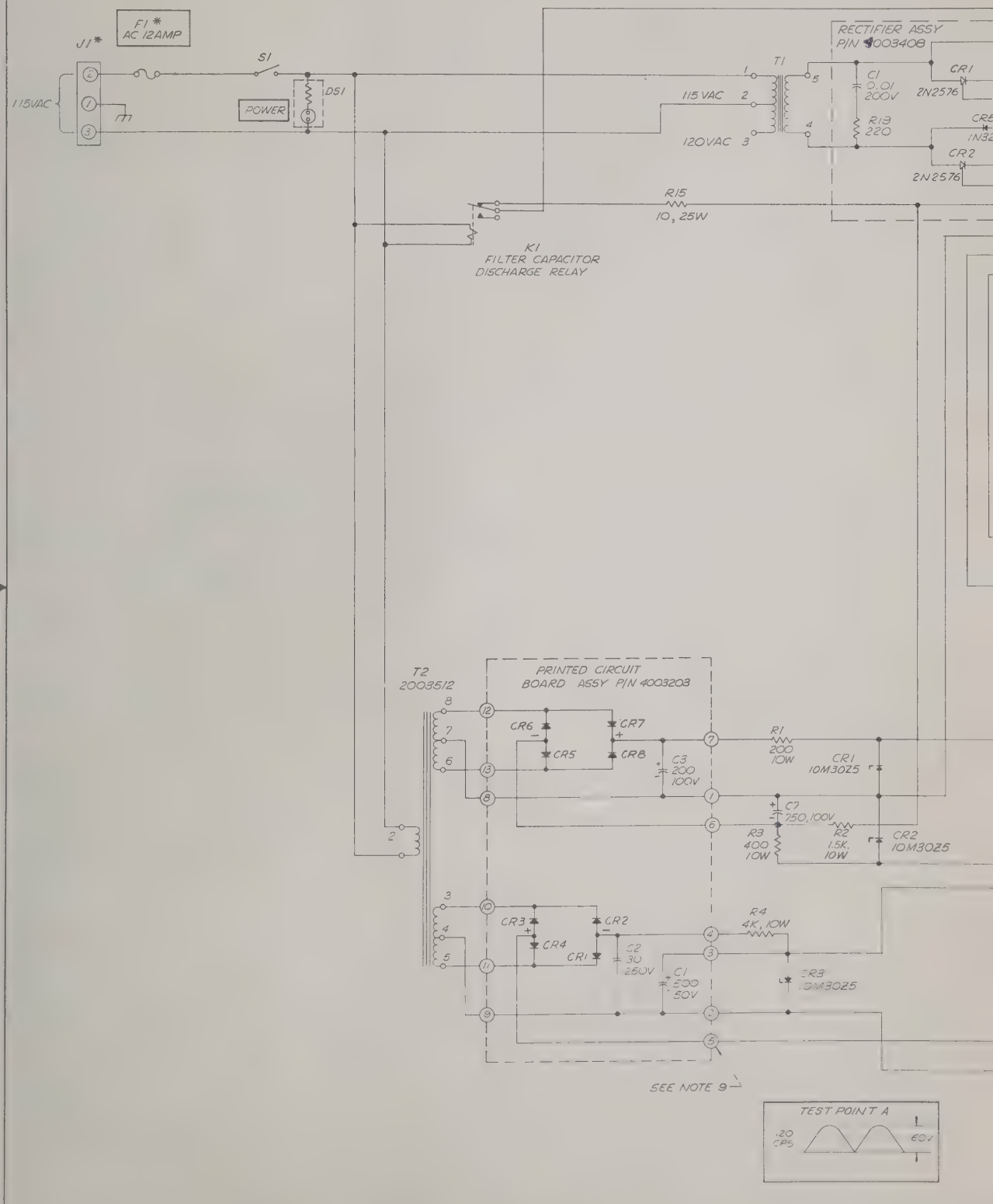
a. Use equivalent parts, as described in the Parts List, Section 5.

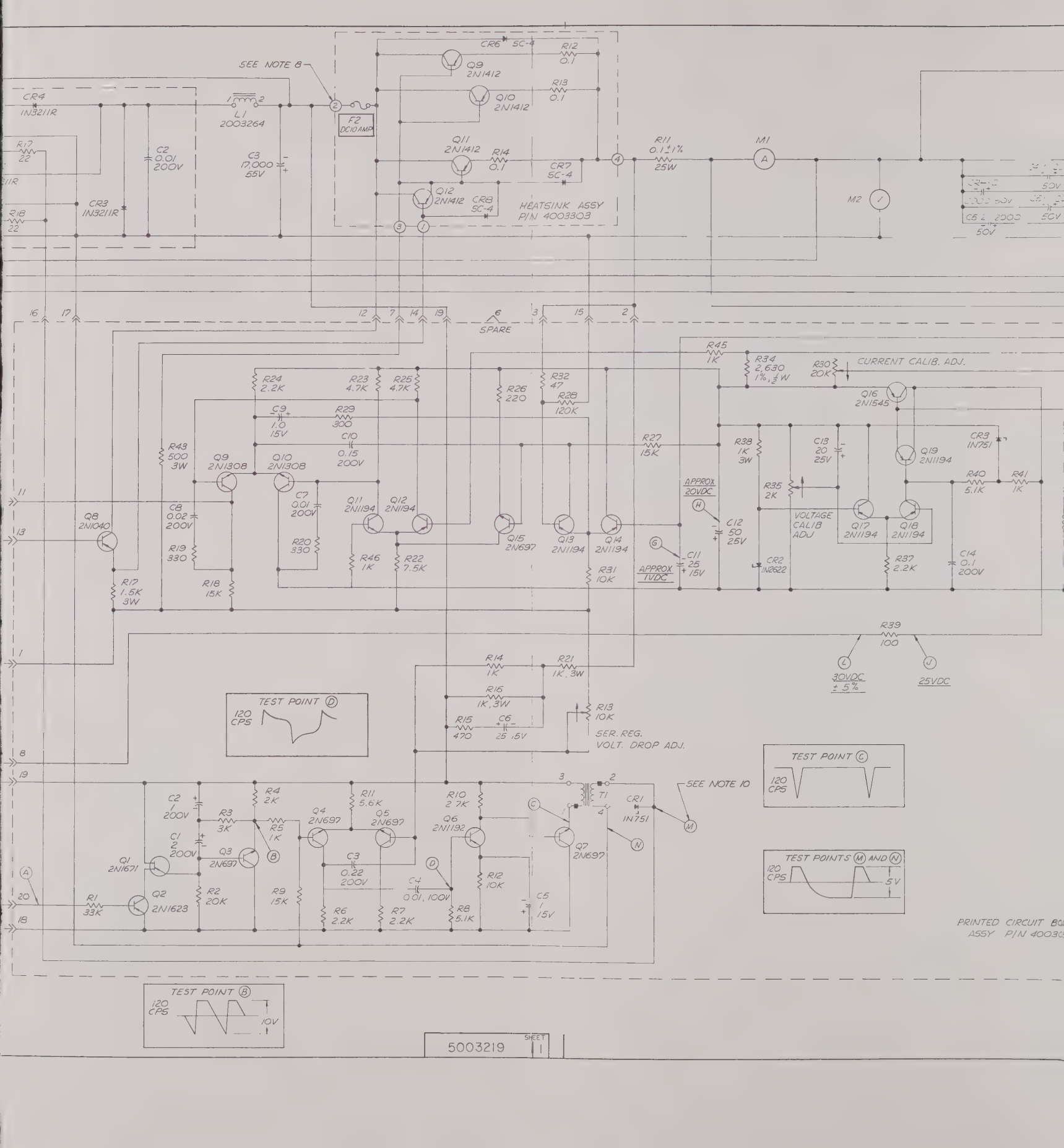
b. Place parts and wiring in same locations as before repair.

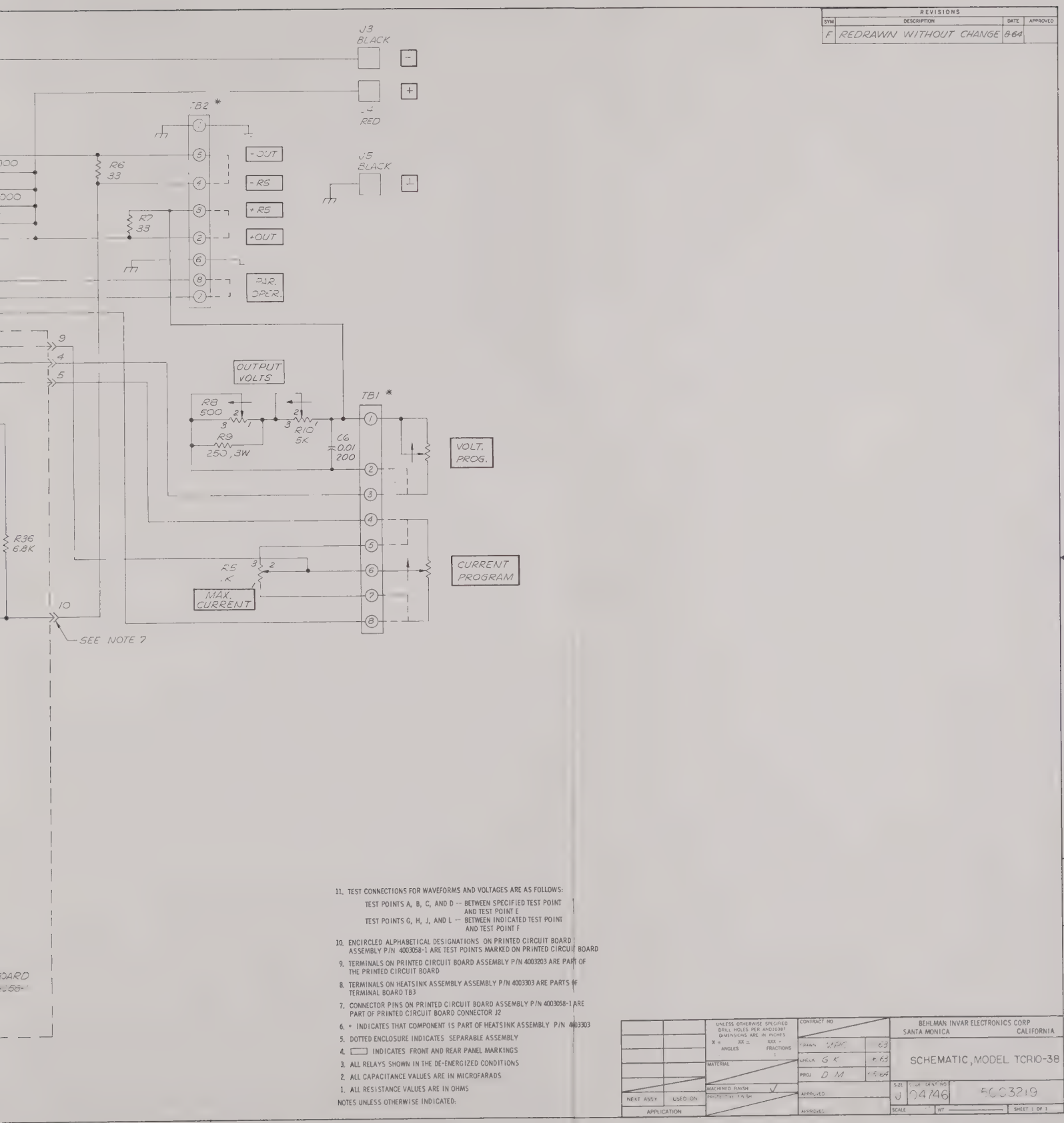
c. Take care to avoid damage, particularly burning insulation, scratching or breaking printed circuits, or pinching wires.

d. When replacing parts on printed circuit boards, do not attempt to unsolder them. Clip the leads to the part to be removed, and solder the new part to the portions of the leads which remain connected to the board.

When a part has been replaced, or if any other type of repair has been accomplished on the power supply, particularly in the regulatory circuits and integral power supply reference voltage circuits, the power supply should be subjected to the appropriate performance check and adjustment procedures of paragraphs 4.4.4 and 4.4.5.


F1 *
AC 12AMP
J1*
115VAC
S1
POWER
DS1
T1
115 VAC 2
120VAC 3
RECTIFIER ASSY
P/N 4003408
C1
0.01
200V
CR1
2N2576
R13
220
CR2
2N2576
R15
10, 25W
K1
FILTER CAPACITOR
DISCHARGE RELAY
T2
2003512
PRINTED CIRCUIT
BOARD ASSY P/N 4003203
CR6
CR7
CR5
CR8
C3
200
100V
R1
200
10W
CR1
10M30Z5
C2
750, 100V
R3
400
10W
R2
1.5K.
10W
CR2
10M30Z5
CR3
CR4
CR1
CR2
C2
30
250V
C1
500
50V
R4
4K, 10W
CR3
10M30Z5
SEE NOTE 9
TEST POINT A
120
CPS
60V


SEE NOTE 8
CR4 IN3211R
L1 2003264
F2 DC10 AMP
CR6 SC-4
Q9 2N1412
Q10 2N1412
Q11 2N1412
Q12 2N1412
CR8 SC-4
CR7 SC-4
R12 0.1
R13 0.1
R14 0.1
R11 0.1 ± 1% 25W
HEATSINK ASSY P/N 4003303
M1
M2
R17 22
R18 22
CR3 IN3211R
C2 0.01 200V
C3 17,000 65V
SPARE
R45 1K
R34 2,630 1%, ½W
R30 20K
CURRENT CALIB. ADJ.
Q16 2N1545
R24 2.2K
R23 4.7K
R25 4.7K
R26 220
R32 47
R28 120K
C9 1.0 15V
R29 300
C10 0.15 200V
R27 15K
R38 1K 3W
C13 20 25V
CR3 IN751
Q19 2N1194
R43 500 3W
Q9 2N1308
Q10 2N1308
R35 2K
R40 5.1K
R41 1K
APPROX 20VDC
C12 50 25V
VOLTAGE CALIB ADJ
Q17 2N1194
Q18 2N1194
Q8 2N1040
C8 0.02 200V
C7 0.01 200V
Q11 2N1194
Q12 2N1194
Q15 2N697
Q13 2N1194
Q14 2N1194
R19 330
R20 330
R46 1K
R22 7.5K
R31 10K
APPROX 1VDC
C11 25 15V
CR2 IN2622
R37 2.2K
C14 0.1 200V
R17 1.5K 3W
R18 15K
R39 100
30VDC ± 5%
25VDC
R14 1K
R21 1K, 3W
R16 1K, 3W
R15 470
C6 25 15V
R13 10K
SER. REG. VOLT. DROP ADJ.
TEST POINT D
120 CPS
TEST POINT C
120 CPS
SEE NOTE 10
C2 1 200V
R3 3K
R4 2K
R11 5.6K
R10 2.7K
T1
CR1 IN751
C1 2 200V
R5 1K
Q4 2N697
Q5 2N697
Q6 2N1192
Q7 2N697
Q1 2N1671
Q3 2N697
C3 0.22 200V
C4 0.01, 100V
R12 10K
R1 33K
Q2 2N1623
R2 20K
R9 15K
R6 2.2K
R7 2.2K
R8 5.1K
C5 1 15V
TEST POINTS M AND N
120 CPS
5V
TEST POINT B
120 CPS
10V
PRINTED CIRCUIT BO
ASSY P/N 40030
5003219
SHEET 1



11. TEST CONNECTIONS FOR WAVEFORMS AND VOLTAGES ARE AS FOLLOWS:
    TEST POINTS A, B, C, AND D -- BETWEEN SPECIFIED TEST POINT AND TEST POINT E
    TEST POINTS G, H, J, AND L -- BETWEEN INDICATED TEST POINT AND TEST POINT F
10. ENCIRCLED ALPHABETICAL DESIGNATIONS ON PRINTED CIRCUIT BOARD ASSEMBLY P/N 4003058-1 ARE TEST POINTS MARKED ON PRINTED CIRCUIT BOARD
9. TERMINALS ON PRINTED CIRCUIT BOARD ASSEMBLY P/N 4003203 ARE PART OF THE PRINTED CIRCUIT BOARD
8. TERMINALS ON HEATSINK ASSEMBLY ASSEMBLY P/N 4003303 ARE PARTS OF TERMINAL BOARD TB3
7. CONNECTOR PINS ON PRINTED CIRCUIT BOARD ASSEMBLY P/N 4003058-1 ARE PART OF PRINTED CIRCUIT BOARD CONNECTOR J2
6. * INDICATES THAT COMPONENT IS PART OF HEATSINK ASSEMBLY P/N 4003303
5. DOTTED ENCLOSURE INDICATES SEPARABLE ASSEMBLY
4. ▭ INDICATES FRONT AND REAR PANEL MARKINGS
3. ALL RELAYS SHOWN IN THE DE-ENERGIZED CONDITIONS
2. ALL CAPACITANCE VALUES ARE IN MICROFARADS
1. ALL RESISTANCE VALUES ARE IN OHMS

NOTES UNLESS OTHERWISE INDICATED:

UNLESS OTHERWISE SPECIFIED DRILL HOLES PER ANSI B94.11M-1979 DIMENSIONS ARE IN INCHES
X ± .1 XX ± .01 XXX ± .005
ANGLES ± 1°
FRACTIONS 1/64
MATERIAL
MACHINED FINISH √
FINISH PER MIL-STD-
NEXT ASSY USED ON
APPLICATION

CONTRACT NO
DRAWN J.P.C. 6-3
CHECK G.K. 6-13
PROJ D.M. 6-64
APPROVED
ASSIGNED

BEHLMAN INVAR ELECTRONICS CORP
SANTA MONICA CALIFORNIA

SCHEMATIC, MODEL TCR10-38

SIZE J DWG NO 04746 5003219
SCALE WT SHEET 1 OF 1

Figure 4-1. Model TCR 10-38 DC Power Supply, Schematic Diagram

SECTION 5

PARTS LIST

5.1 INTRODUCTION

5.1.1 This section provides the information necessary for procuring replacements for all electrical parts of the Model TCR 10-38 Power Supply. The components tabulated in the parts list are grouped by assembly, and arranged in each assembly in alpha-numerical sequence according to reference designation.

5.2 VENDORS' CODES

5.2.1 Approved vendors' codes, as listed in Federal Cataloging Handbook H4-1, are used in the parts list and are listed below in numerical sequence.

FED CODE	VENDOR'S NAME AND ADDRESS
00656	Aerovox Corp. New Bedford, Mass.
03739	Eldema El Monte, Calif.
04009	Arrow-Hart and Hegeman Electric Co. Hartford 6, Conn.
04713	Motorola, Inc. Phoenix, Arizona
04746	Behlman-Invar Electronics Corp. Santa Monica, Calif.
06228	Texas Instruments, Inc. Dallas, Texas
08289	Delbert Blinn Box 757 Pomona, Calif.
12697	Clarostat Mfg. Co., Inc. Dover, New Hampshire
12974	Westcap Electrolytic Div. Electrocap Corp. Oakland, Calif.
14099	Semtech Corp. Newberry Park, Calif.
14193	California Resistor Co. Santa Monica, Calif.
14655	Cornell Dubilier Electric Co. South Plainfield, N.J.
14752	Electro Cube Inc. South Pasadena, Calif.
24446	General Electric Co. Schenectady 5, N.Y.
31356	J.B.T. Instrument, Inc. New Haven 8, Conn.
37492	P.R. Mallory and Co., Inc. Rosemead, Calif.
44655	Ohmite Mfg. Co. Skokie, Ill.
70903	Belden Mfg. Co. Chicago 44, Ill.
71785	Cinch Mfg. Corp. Chicago 24, Ill.

FED CODE	VENDOR'S NAME AND ADDRESS
75915	Littelfuse, Inc. Des Plaines, Ill.
80294	Bourns Laboratories, Inc. Riverside, Calif.
81095	Raytheon Mfg. Co. Industrial Apparatus Div. Los Angeles 29, Calif.
85474	Superior Electric Co. Bristol, Conn.
91637	Dale Products, Inc. Columbus, Nebraska
91662	Elco Corp. Philadelphia 24, Pa.
94312	National Moldite Co. Hillside, N.J.

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
	5003298	Assembly, D.C. Power Supply	Ref	04746
C2,C6	210BC103M	. CAPACITOR, FXD, PLASTIC, 0.01 µf ±20%, 200 wvdc	3	14752
C3	TS19279	. CAPACITOR, FXD, ELEC, 17,000 µfd, 55 wvdc	1	37492
C4-1, C4-2, C5-1, C5-2	NV50P20	. CAPACITOR, FXD, ELEC, 200 µfd, 50 wvdc	4	12974
C7	TS19305-01	. CAPACITOR, FXD, ELEC, 750 µf, 100 wvdc .	1	37492
CR1, CR2, CR3	10M30Z5	. SEMICONDUCTOR DEVICE, DIODE, Zener diode	3	04713
DS1	BG3-RC-B-2H-35K	. LAMP, INDICATOR, red	1	03739
J2	00-5007-020-189	. CONNECTOR, RECEPTACLE, ELECT, printed circuit board	1	91662
J3	2003136-2	. POST, BINDING, black.	1	04746
J4	2003136-1	. POST, BINDING, red	1	04746
J5	DF30BC	. POST, BINDING, black.	1	85474
K1	1400219	. RELAY, ARMATURE, 115 vac coil, contact arrangement 2C.	1	04746
L1	2003264	. FILTER REACTOR	1	04746
M1	1500011	. AMMETER, 0-12 amps	1	04746
M2	1500014	. VOLTMETER, 0-50 volts dc	1	04746
R1	1723	. RESISTOR, FXD, WW, 200 ohms, 10w	1	44655
R2	1740	. RESISTOR, FXD, WW, 1.5k ohms, 10w	1	44655
R3	1728	. RESISTOR, FXD, WW, 400 ohms, 10w	1	44655
R4	1747	. RESISTOR, FXD, WW, 4k ohms, 10w.	1	44655
R5	A43-1000	. POTENTIOMETER, WW, 1k ohms, 2w	1	12697
R6,R7		. RESISTOR, FXD, COMP, 33 ohms, ±5%, 1/2w	2	44655
R8/R10	BI140039	. POTENTIOMETER, WW, DUAL CONCENTRIC, inner shaft element 500 ohms, 2w; outer shaft element 5k ohms, 2w.	1	31356
R9		. RESISTOR, FXD, COMP, 220 ohms ±5%, 1/2w	1	44655

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
R11	RH-25	. RESISTOR, FXD, WW, 0.1 ohms ±1%, 25w. .	1	91637
R15	0200B	. RESISTOR, FXD, WW, 10 ohms, 25w.	1	44655
S1	ST42A	. SWITCH, TOGGLE, SPST	1	04009
T1	2003406	. TRANSFORMER, POWER, STEP-DOWN. . . .	1	04746
T2	2003153	. TRANSFORMER, POWER, STEP-DOWN. . . .	1	04746
	17408	. AC LINE CORD, with integral molded plug. .	1	70903
	7484	. CONNECTOR, PLUG, ELECTRICAL (used with ac line cord)	1	94312
	4003058-1	. MAIN PRINTED CIRCUIT BOARD ASSY	1	04746
	3003408	. DIODE ASSY	1	04746
	4003303	. HEATSINK ASSY.	1	04746
	4003058-1	Main Printed Circuit Board Assy	Ref	04746
C1	210B1C205M	. CAPACITOR, FXD, PLASTIC, 2.0 µf ±20%, 200 wvdc	1	14752
C2	210B1C105M	. CAPACITOR, FXD, PLASTIC, 1.0 µf ±20%, 200 wvdc	1	14752
C3	210B1C224M	. CAPACITOR, FXD, PLASTIC, 0.22 µf ±20%, 200 wvdc	1	14752
C4,C7	WMF1S1	. CAPACITOR, FXD, PLASTIC, 0.01 µf ±10%, 100 wvdc	2	14655
C5,C9	CRE-450A	. CAPACITOR, FXD, ELEC, 1 µf, 15 wvdc . . .	2	00656
C6,C11	NLW25-15	. CAPACITOR, FXD, ELEC, 25 µf, 15 wvdc . .	2	14655
C8	210B1C203M	. CAPACITOR, FXD, PLASTIC, 0.02 µf ±20%, 200 wvdc	1	14752
C10	210B1C154M	. CAPACITOR, FXD, PLASTIC, 0.15 µf ±20%, 200 wvdc	1	14752
C12	NLW50-25	. CAPACITOR, FXD, ELEC, 50 µf, 25 wvdc . .	1	14655
C13	NLW20-25	. CAPACITOR, FXD, ELEC, 20 µfd, 25 wvdc .	1	14655
C14	210B1C104M	. CAPACITOR, FXD, PLASTIC, 0.10 µf ±20%, 200 wvdc	1	14752
CR1, CR3	1N751	. SEMICONDUCTOR DEVICE, DIODE, Zener diode	2	04713
CR2	1N2622	. SEMICONDUCTOR DEVICE, DIODE, Zener diode	1	04713

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
Q1	2N1671	. TRANSISTOR	1	24446
Q2	2N1623	. TRANSISTOR	1	81095
Q3,Q4, Q5,Q7, Q15	2N697	. TRANSISTOR	5	04713
Q6	2N1192	. TRANSISTOR	1	04713
Q8	2N1040	. TRANSISTOR	1	06228
Q9,Q10	2N1308	. TRANSISTOR	2	06228
Q11,Q12, Q13,Q14, Q17,Q18, Q19	2N1194	. TRANSISTOR	7	04713
Q16	2N1545	. TRANSISTOR	1	04713
R1		. RESISTOR, FXD, COMP, 33K ohms ±5%, 1/2w	1	44655
R2		. RESISTOR, FXD, COMP, 20K ohms ±5%, 1/2w	1	44655
R3		. RESISTOR, FXD, COMP, 3K ohms ±5%, 1/2w	1	44655
R4		. RESISTOR, FXD, COMP, 2K ohms ±5%, 1/2w	1	44655
R5,R14, R41,R45, R46		. RESISTOR, FXD, COMP, 1K ohms ±5%, 1/2w	5	44655
R6,R7, R24,R37		. RESISTOR, FXD, COMP, 2.2K ohms ±5%, 1/2w	4	44655
R8,R40		. RESISTOR, FXD, COMP, 5.1K ohms ±5%, 1/2w	2	44655
R9,R12, R31		. RESISTOR, FXD, COMP, 10K ohms ±5%, 1/2w	3	44655
R10		. RESISTOR, FXD, COMP, 2.7K ohms ±5%, 1/2w	1	44655
R11		. RESISTOR, FXD, COMP, 5.6K ohms ±5%, 1/2w	1	44655
R13	3067P-1-103	. POTENTIOMETER, WW, 10K ohms	1	80294
R15		. RESISTOR, FXD, COMP, 470 ohms ±5%, 1/2w	1	44655

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
R16,R21, R38	4423	. RESISTOR, FXD, WW, 1K ohms ±5%, 3w . . .	3	44655
R17		. RESISTOR, FXD, COMP, 1.5K ohms ±5%, 3w	1	44655
R18,R27		. RESISTOR, FXD, COMP, 15K ohms ±5%, 1/2w	2	44655
R19,R20		. RESISTOR, FXD, COMP, 300 ohms ±5%, 1/2w	2	44655
R22		. RESISTOR, FXD, COMP, 7.5K ohms ±5%, 1/2w	1	44655
R23,R25		. RESISTOR, FXD, COMP, 4.7K ohms ±5%, 1/2w	2	44655
R26		. RESISTOR, FXD, COMP, 220 ohms ±5%, 1/2w	1	44655
R28		. RESISTOR, FXD, COMP, 160K ohms ±5%, 1/2w	1	44655
R29		. RESISTOR, FXD, COMP, 300 ohms ±5%, 1/2w	1	44655
R30	3067P-1-203	. POTENTIOMETER, WW, 20k ohms	1	80294
R32		. RESISTOR, FXD, COMP, 47 ohms ±5%, 1/2w	1	44655
R33		. RESISTOR, FXD, COMP, 1/2w (value determined by test).	1	44655
R34	Type SA-10	. RESISTOR, FXD, WW, 2.630 ohms ±1%, 1/2w	1	14193
R35	275-1-202	. POTENTIOMETER, WW, 2K ohms	1	80294
R36		. RESISTOR, FXD, COMP, 6.8K ohms ±5%, 1/2w	1	44655
R39		. RESISTOR, FXD, COMP, 100 ohms ±5%, 1/2w	1	44655
R42		. RESISTOR, FXD, COMP, 130K ohms ±5%, 1/2w	1	44655
R43		. RESISTOR, FXD, WW, 500 ohms ±5%, 3w	1	44655
T1	2003375	. TRANSFORMER, PULSE	1	04746

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
XQ1 thru XQ15, XQ17, XQ18, XQ19	TP501	. PAD, TRANSISTOR	18	08289
	4003057	. PRINTED CIRCUIT BOARD	1	04746
	3003408	Diode Assy	Ref	04746
C1	210BC103M	. CAPACITOR, FXD, PLASTIC, 0.01 µf ±20%, 200 wvdc	1	14752
CR1, CR2	2N2576	. SEMICONDUCTOR DEVICE, TRIODE, silicon controlled-rectifier	2	04713
CR3, CR4, CR5	BR3211R	. SEMICONDUCTOR DEVICE, DIODE	3	04746
R17, R18		. RESISTOR, FXD, COMP, 22 ohms ±20%, 1/2w	2	44655
R19		. RESISTOR, FXD, COMP, 220 ohms ±5%, 1/2w	1	44655
	4003203	. PRINTED CIRCUIT BOARD ASSY	1	04746
C1	BR500-50	. . CAPACITOR, FXD, ELEC, 500 µf, 50 wvdc	1	14655
C2	BR30-250	. . CAPACITOR, FXD, ELEC, 30 µf, 250 wvdc	1	14655
C3	TS19306-00	. . CAPACITOR, FXD, ELEC, 200 µf, 100 wvdc	1	37492
CR1 thru CR8	SC-4	. . SEMICONDUCTOR DEVICE, DIODE	8	14099
	3003202	. . PRINTED CIRCUIT BOARD	1	04746
	4003303	Heatsink Assy	Ref	04746
CR6, CR7, CR8	SC-4	. SEMICONDUCTOR DEVICE, DIODE	3	14099
F1	314012	. FUSE, CARTRIDGE, 12 amp (3AB)	1	75915
F2	311010	. FUSE, CARTRIDGE, 10 amp (3AG slo-blo)	1	75915

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
J1	7486	. CONNECTOR, RECEPTACLE, ELECT.	1	75915
Q9,Q10, Q11, Q12	2N1412	. TRANSISTOR	4	04713
R12,R13, R14	000-0296	. RESISTOR, FXD, WW, 0.1 ohm ±3%, 25w ..	3	04746
TB1, TB2	8-140-Y	. TERMINAL BOARD, 8 term.	2	71785
	140-J1	. JUMPER, TERMINAL BOARD (used with TB1 and TB2)	6	71785
TB3	4-140-3/4W	. TERMINAL BOARD, 4 term.	1	71785
XF1, XF2	341001	. FUSEHOLDER	2	75915

MP MASTER
MA29438